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Validation Study of Armed Services Vocational Aptitude Battery (ASVAB) Selector Composites: Operations Control (OA) Occupational Group

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The purpose of this study was to validate Armed Services Vocational Aptitude Battery (ASVAB) composites for five of the seven ratings of the Operations Control (OA) occupational group. The ASVAB consists of the following ten tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI).

The study recommends (1) replacing the operational selector composite, VE + AR, with VE + MK + CS for the Operations Specialist (OS) and Signalman (SM) ratings, (2) retaining the operational selector composite, AR + 2MK + GS, for the Air Traffic Controller (AC) and Aviation Antisubmarine Warfare Operator (AW) ratings, and (3) replacing the operational selector composite, VE + AR, with AR + 2MK + GS for the Quartermaster (QM) rating. Adopting these recommendations (including the recommended minimum qualifying scores) and those made earlier for the Radioman (RM) and Aerographer's Mate (AG) ratings should reduce attrition and the number of selector composites used by the OA group from three to two.

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FOREWORD

This study was conducted in response to a request from the Bureau of Naval Personnel (PERS-23) to validate the Armed Services Vocational Aptitude Battery (ASVAB) selection criteria for the ratings of the Operations Control (OA) occupational group.

This investigation was sponsored by PERS-234 and funded by program element 090000N, work unit WRB1008. Results are intended for use by BUPERS, the OA school personnel, and the research community.

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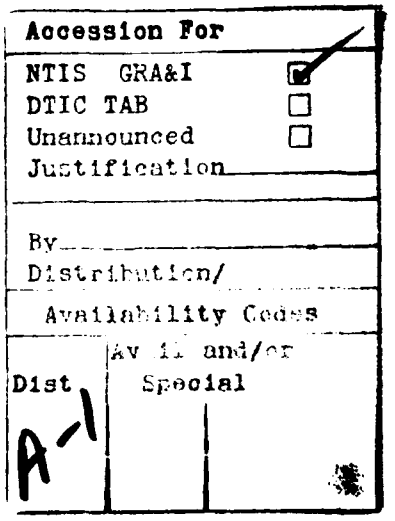

SUMMARY

Problem

A validation study of Armed Services Vocational Aptitude Battery (ASVAB) selector composites for the ratings of the Operations Control (OA) occupational group was requested by the Bureau of Naval Personnel (PERS-23). Concerns about high attrition in the Class "A" schools prompted the request. The ASVAB consists of the following ten tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI).

This study focuses on the Air Traffic Controller (AC), Aviation Antisubmarine Warfare Operator (AW), Operations Specialist (OS), and Signalman (SM) ratings. A study for the Quartermaster (QM) rating was not requested because one was conducted in 1986; however, the rating was included in this study for secondary analyses. While studies for the Aerographer's Mate (AG) and Radioman (RM) ratings were conducted earlier, a summary of findings are presented for this report in an appendix.

Objective

The objectives of this research were to (1) validate the operational ASVAB selector composites against AC, AW, OS, and SM "A" school performance measures (QM is included in secondary analyses), (2) identify and evaluate alternative ASVAB composites that would be more effective for determining qualification for "A" school assignment, (3) reduce, if analyses support, the number of selector composites used by the OA group (three are in use), and (4) determine minimum qualifying scores for recommended composites that would reduce "A" school attrition.

Approach

Each "A" school sample was randomly divided into a test selection sample and a hold-out sample. Two methods used a multiple regression procedure with the test selection sample to determine the most valid ASVAB selector composite. The first, Method I, did not correct for restriction in range of ASVAB test scores used to select students, while the second, Method II, did. Experimental composites identified from Methods I and II and the operational selector composite were then validated in the hold-out sample. Validities were compared after correcting for restriction in range. When replacing the operational composite was warranted (assessed from increase in validity or expected improvement in the "A" school graduation rate), an existing Navy operational selector composite most similar to the experimental composite was chosen as a candidate replacement. The candidate replacement was recommended for use if it performed as well as the experimental composite.

Composites evaluated for the AC, AW, OS, and SM "A" schools were evaluated for the QM "A" school.

Minimum qualifying scores for recommended composites and for operational composites that were adequate were evaluated on the basis of (1) attrition rate, (2) waiver rate, (3) yearly input

requirement, (4) percentage of the recruit population qualifying for school selection, and (5) number of school graduates disqualified from school selection.

Results and Conclusions

For the AC and AW "A" schools, the operational composite, AR+2MK+GS, was adequate. For the OS and SM "A" schools, VE+MK+CS (recommended for RM) had higher validity than the operational composite, VE+AR. For the QM "A" school, AR+2MK+GS (recommended for AG) had higher validity than the operational composite, VE+AR.

Recommendations

The following recommendations are addressed to PERS-23:

1. For the AC and AW "A" schools, the operational composite, AR+2MK+GS, is recommended for continued use. This composite is also recommended to replace the operational selector composite, VE+AR, for the QM "A" school. The recommended minimum qualifying scores for AR+2MK+GS are (1) 214 for AC, (2) 202 for AW, and (3) 193 for QM.

2. For the OS and SM "A" schools, VE+MK+CS is recommended to replace the operational selector composite, VE+AR. The recommended minimum qualifying scores for VE+MK+CS are 153 for OS and 147 for SM.

Adopting these recommendations and those made from the RM and AG studies should reduce attrition for the OA occupational group and the number of operational selector composites from three to two.

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INTRODUCTION

Background and Problem

This Armed Services Vocational Aptitude Battery (ASVAB) validation study was conducted for the ratings of the Operations Control (OA) occupational group. Bureau of Naval Personnel (PERS 23) requested the study because of high attrition in the "A" schools.

The ASVAB has been the personnel selection and classification instrument for all the military services since 1976. The paper-and-pencil battery consists of the following ten tests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop Information (AS), Mathematics Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI). These tests, described briefly in Table 1, are used by each service in various combinations (composites) to select recruits into military occupations. The Navy's 11 ASVAB operational selector composites (see Table 2) constitute one of six weighted components of CLASP (Classification and Assignment within PRIDE--Personalized Recruiting for Immediate and Delayed Enlistment), the Navy's automated classification system that assigns recruits into 14 occupational groups.

Before CLASP and the organization of occupational groups, ASVAB validation studies were conducted for individual ratings without regard for other ratings with similar ability requirements. As a result, when occupational groups were formed, some, such as the (OA) occupational group, had more than one ASVAB operational selector composite. However, because some ASVAB composites are highly correlated, one composite may be as effective for "A" school selection as another. Therefore, the current strategy is to validate ASVAB composites for all ratings of an occupational group with the objective of reducing the number of selector composites (for groups with more than one) when possible.

The ratings of the OA occupational group are listed below:

1. Air Traffic Controller (AC)
2. Aerographer's Mate (AG)
3. Aviation Antisubmarine Warfare Operator (AW)
4. Operations Specialist (OS)
5. Quartermaster (QM)
6. Radioman (RM)
7. Signalman (SM)

Table 1

Content of ASVAB Tests

Test	Abbreviation	Description
General Science	GS	A 25-item text of knowledge of the physical (13 items) and biological (12 items) sciences--11 minutes.
Arithmetic Reasoning	AR	A 30-item test of ability to solve arithmetic word problems--36 minutes.
Word Knowledge[a]	WK	A 35-item test of knowledge of vocabulary, using words embedded in sentences (11 items) and synoyms (24 items)--11 minutes.
Paragraph Comprehension[a]	PC	A 15-item test of reading comprehension--13 minutes.
Numerical Operations	NO	A 50-item speed test of ability to add, subtract, multiply, and divide one- and two-digit numbers--3 minutes.
Coding Speed	CS	An 84-item speed test of ability to recognize numbers associated with words from a table--7 minutes.
Auto and Shop Information	AS	A 25-item test of knowledge of automobiles, shop practices, and use of tools--11minutes.
Mathematics Knowledge	MK	A 25-item test of knowledge of algebra, geometry, fractions, decimals, and exponents--24 minutes.
Mechanical Comprehension	MC	A 25-item test of knowledge of mechanical and physical principles--19 minutes.
Electronics Information	EI	A 20-item test of knowledge of electronics, radio, and electrical principles and information--9 minutes.

[a]Verbal score: VE = WK + PC (raw scores).

Table 2

Navy Operational ASVAB Selector Composites

Composite	Composite Name
VE+AR	General Technical
VE+MC+AS	Mechanical
AR+MK+EI+GS	Electronics
VE+NO+CS	Clerical
AR+2MK+GS	Basic Electricity and Electronics
MK+AS	Engineering
VE+AR+NO+CS	Cryptologic Technician
VE+MK+GS	Hospitalman
AR+MC+AS	Machinery Repairman
VE+AR+MVC	Submarine
VE+MK+CS	Business/Clerical[a]

Note. See Table 1 for full test names.

[a]Student Testing Program composite implemented July 1987.

The current study focuses on the AC, AW, OS, and SM "A" schools. A validation study for the QM "A" school was not requested because one was conducted recently (Foley & Held, 1986). However, the current study includes the QM "A" school in secondary analyses. Validation studies for the RM and AG "A" schools were conducted just prior to this study (Held, 1987; Monzon, 1987). A summary of the findings are presented in Appendix A of this report.

The seven "A" schools of the OA occupational group use three operational selector composites: (1) AR+2MK+GS for AC, AG, and AW, (2) VE+AR for OS, SM, and QM, and (3) VE+NO+CS for RM. For AG, AR+2MK+GS replaced VE+AR (Monzon, 1987, see Appendix A). For RM, VE+MK+CS was recommended to replace VE+NO+CS (Held, 1987, see Appendix A). Assuming the recommendation for RM is followed, this would still leave three operational selector composites for the OA group.

Objectives

The objectives of this research were to (1) validate the ASVAB operational selector composites against AC, AW, OS, and SM "A" school performance measures (QM is included in secondary analyses), (2) identify and evaluate alternative ASVAB composites that would be more effective for determining qualification for "A" school assignment, (3) reduce, if analyses support, the

number of selector composites used by the OA group (three are in use), and (4) determine minimum qualifying scores for recommended composites that would reduce "A" school attrition.

APPROACH

Predictors

The predictors used in this study were the 10 tests of the ASVAB (Table 1). A technical description of parallel Forms 11, 12, 13, introduced in October 1984 to replace Forms 8, 9, 10, can be found in Prestwood, Vale, Massey, and Welsh (1985). Standardized scores were used for all analyses.

Criterion

The criterion, or performance measures, for the "A" schools was final school grade (FSG), which was the average of scores on all tests (usually weekly) including the final comprehensive exam. Although FSG is on a scale of 0 to 100, passing scores are usually between 70 and 100.

Attrites were retained for the analyses to provide a representative sample. However, because their FSGs are usually recorded as zero or the score received at the time of disenrollment, they were replaced with one estimated by a mathematical procedure. This procedure, developed by Abrahams and Alf (in preparation), is detailed in Appendix B.

Samples

The "A" schools provided data for students who graduated or attrited from June 1983 through September 1987. These data were matched with data on the Navy Integrated Training Resources and Administration System (NITRAS) data tapes to verify or obtain Student Action Codes for graduates and attrites. The resulting samples were further matched with Defense Manpower Data Center (DMDC) data tapes to obtain ASVAB test scores and other data, where needed.

Table 3 lists, for the AC, AW, OS, and SM "A" school samples, the number of students and the attrition rate. Also listed are the operational selector composites.

Table 3

Class "A" School Samples

School	Number of Students	Attrition Rate[a] (%)	Operational Selector Composite[b]
AC	751	36	AR+2MK+GS
AW	908	18	AR+2MK+GS
OS	2076	14	VE+AR
SM	1703	7	VE+AR

[a]Academic and nonacademic attrites were combined for this study.

[b]See Table 1 for full test names.

Data Analyses

The students from each "A" school sample were randomly assigned to a test selection sample (60% of the students) and a hold-out sample (40% of the students). Prior to this assignment, students were sorted to ensure that the test selection and hold-out samples had equal percentages of graduates and attrites (academic and nonacademic).

Two methods were used with the test selection sample to determine the ASVAB composite most predictive of FSG. Both methods use a forward stepwise multiple regression procedure in which the prediction equation starts with the ASVAB test that has the highest correlation with FSG followed by tests that provide the largest increase in the multiple correlation.[1] The first four tests to enter the equation were designated as the experimental selector composite. Method I did not correct for restriction in range of scores for ASVAB tests used to select students, while Method II did (Method II allows an unbiased selection of ASVAB tests into the prediction equation). The correction procedure, which uses multivariate formulas (Lawley, 1943), is explained in Appendix C. The multiple regression results for both Methods I and II are in Appendix D. Both procedures use AW "A" school data.

For each "A" school, the experimental composites identified by Methods I and II and the operational selector composite were cross-validated in the hold-out samples using a unit weight for each test (unit weights add stability in generalizing to future samples, whereas exact weights derived from regression analyses are sample specific). Validities were compared after correcting for (1) coarse grouping (assigning attrites a single FSG reduces variance and, therefore, correlations) and (2) restriction in range of test scores (to obtain the validity for a typical recruit applicant group rather than a selected sample).

Candidate composites were evaluated for replacing an operational composite when an experimental composite demonstrated an appreciable gain in validity (.05 or greater) or expected gain in the "A" school graduation rate (2% or greater).[2]

Candidate replacement composites were chosen from the 11 existing Navy operational selector composites based on their similarity to the experimental composite. If the validities for the candidate and experimental composites were comparable, the candidate composite was proposed as a replacement for the operational selector composite.

For the QM "A" school, the data analyzed by Foley and Held (1986) using a test selection and hold-out sample were reanalyzed as a total sample (N = 409) to validate proposed composites for the AC, AW, OS, and SM ratings and adequate operational selector composites (including the QM operational selector composite).

Finally, minimum qualifying scores were evaluated for operational composites that were adequate and for proposed replacement composites. Expectancy tables using "A" school data were developed for operational composites; theory-based expectancy tables (Taylor & Russell, 1939) were developed for proposed composites. A number of factors were considered in evaluating

[1]For the multiple regression, WK and PC were combined into the ASVAB Verbal (VE) composite.

[2]The Taylor Russell tables (1939) were used to translate gain in validity into expected gain in the graduation rate.

minimum qualifying scores: (1) attrition rate, (2) waiver rate, (3) planned input for fiscal year (FY) 1987, (4) the percentage of the recruit population qualifying at a particular score, and (5) the number of school graduates disqualified as a result of raising the score (operational composite).

RESULTS AND CONCLUSIONS

Composite Validity

The experimental composites identified by Methods I and II using the AC, AW, OS, and SM test selection samples and each "A" school's operational selector composite are listed in Table 4.

Table 4

Experimental Composites for the AC, AW, OS, and SM Test Selection Samples and "A" School Operational Composites

School	Experimental Composite		Operational Selector Composite
	Method I	Method II	
AC	AR+MC+VE+MK	AR+GS+MC+NO	AR+MK+GS
AW	MK+AR+CS+GS	MK+AR+CS+MC	AR+2MK+GS
OS	MK+AS+CS+NO ◄——►	MK+AS+CS+NO	VE+AR
SM	MK+CS+EI+VE ◄——►	MK+CS+VE+EI	VE+AR

Notes.
1. See Table 1 for full test names.
2. Arrows indicate that Methods I and II identified the same composite.

Table 5 lists the validities (uncorrected and corrected) for the experimental and operational selector composites for the AC, AW, OS, and SM hold-out samples.

Comparing corrected validities, for the AC "A" school, the validity of .67 for the most valid experimental composite, AR+MC+VE+MK (Method I), was .04 higher than the validity of .63 for the operational composite, AR+2MK+GS, which translated into less than a 2-percent expected gain in the graduation rate. For the AW "A" school, the validity of .64 for the most valid experimental composite, MK+AR+CS+MC (Method II), was .04 higher than the validity of .60 for the operational composite, AR+2MK+GS, which translated into less than a 1-percent expected gain in the graduation rate. For both the AC and AW "A" schools, the experimental composites did not meet either criterion for replacing an operational composite (.05 gain in validity or 2% expected gain in the graduation rate).

Table 5

Experimental and Operational Selector Composite Validities for the AC, AW, OS, and SM Hold-out Samples

School	Experimental Composite				Operational Selector Composite	
	Method I		Method II			
	r_u	r_c	r_u	r_c	r_u	r_c
AC	.45	.67	.39	.64	.36	.63
AW	.41	.61	.48	.64	.41	.60
OS	.31	.39	-	-	.18	.29
SM	.31	.40	-	-	.20	.33

Notes

1. See Table 4 for the tests in the experimental composites. Correlations are not listed when Methods I and II identified the same composite.

2. Both r_u and r_c (Pearson product-moment correlations uncorrected and corrected for restriction in range, respectively) are corrected for coarse grouping. Appendix B (Step 4) details the coarse grouping correction procedure.

3. Univarate formulas obtained from Guilford (1965, pp. 340-345) were used to calculate r_c. Case I was used for the operational selector composites; Case III, for the experimental composites.

For the OS "A" school, the validity of .39 for the experimental composite, MK+AS+CS+NO (Methods I and II), was .10 higher than the validity of .29 for the operational selector composite, VE+AR, which translated into a 2-percent expected gain in the graduation rate. For the SM "A" school, the validity of .40 for the experimental composite, MK+CS+EI+VE (Methods I and II), was .07 higher than the validity of .33 for the operational composite, VE+AR, which translated into less than a 1-percent expected gain in the graduation rate. For both the OS and SM "A" schools, gains in validity for the experimental composites (additionally, gain in expected graduation rate for OS) were sufficient to propose replacing the operational selector composite.

Candidate Composite Selection and Evaluation: OS and SM "A" Schools

For the OS and SM "A" schools, where replacing the operational selector composite was warranted, the existing Navy composites (Table 2) were examined to determine which were most similar to the experimental composites. An existing Navy operational composite is chosen for a school because implementing the statistically derived composite could result in an unmanageable number of Navy operational selector composites over the course of numerous validation studies.[3]

[3]A new composite could be implemented for the Navy, as in the case of the Business/Clerical composite (see Table 2), if the tests of an experimental composite (not found in a Navy operational composite) were consistently derived as the experimental composite for a number of schools in the same or similar occupational groups.

For the OS "A" school, the Engineering composite, MK+AS, and the Business/Clerical composite, VE+MK+CS, were chosen as candidate replacement composites because each contained two of the tests in the experimental composite, MK+AS+CS+NO.

For the SM "A" school, the Business/Clerical composite, VE+MK+CS, was chosen as a candidate replacement composite because it contained three of the four tests in the experimental composite, MK+CS+EI+VE.

At this point, only VE+MK+CS was considered as a candidate replacement composite for the OS and SM "A" schools because adopting MK+AS for OS would increase, rather than reduce, the number of selector composites used for the OA occupational group (VE+MK+CS, recommended for the RM "A" school, was counted as one of the three existing OA operational selector composites). The validities (both uncorrected and corrected for restriction in range) for VE+MK+CS for the OS and SM hold-out samples are listed in Table 6.

Table 6

Candidate Composite (VE+MK+CS) Validities for the OS and SM Hold-out Samples

	Validity	
School	Uncorrected (r_u)	Corrected (r_c)
OS	.27	.35
SM	.30	.40

Comparing corrected validities for the OS "A" school, the validity of .35 for VE+MK+CS was .06 higher than the validity of .29 for the operational composite, VE+AR (see Table 5 for operational composite validities). For SM, the validity of .40 for VE+MK+CS was .07 higher than the validity of .33 for the operational composite, VE+AR. For both the OS and SM "A" schools, the gains in validity for VE+MK+CS were sufficient to propose that VE+MK+CS replace the operational selector composite, VE+AR.

Candidate Composite Selection and Evaluation: QM "A" School

Three composites were validated for the QM "A" school: (1) the proposed selector composite for the OS and SM "A" schools, VE+MK+CS, (2) the operational selector composite found adequate for the AC and AW "A" schools, AR+2MK+GS, and (3) the QM operational selector composite, VE+AR. Correcting for restriction in range, the validity of .74 for AR+2MK+GS was .04 higher than the validity of .70 for VE+AR. The validity for VE+MK+CS was .67, which was lower than the validity for the operational composite. The .04 gain in validity for AR+2MK+GS translated into a 2-percent expected gain in the graduation rate, which was sufficient to propose that AR+2MK+GS replace the operational selector composite, VE+AR.

Minimum Qualifying Scores: AC and AW "A" Schools

For the AC and AW "A" schools, where the operational selector composite, AR+2MK+GS, was adequate, the impact of raising the minimum qualifying score was assessed using expectancy tables developed from the school data. For a range of composite scores that include the current minimum qualifying score, these tables (Appendix E) present graduation and attrition rates for the "A" school samples and expected graduation and attrition rates for the recruit population (expected rates are based on school sample rates).

For the AC "A" school (Table E-1), the attrition rate was 36 percent, which warrants a raise in the minimum qualifying score. Raising the minimum qualifying score for AR+2MK+GS from 206 to 214 (the AR+2MK+GS minimum qualifying score recommended for the AC "A" school) would have increased the graduation rate by 4 percent (from 65% to 69%). However, this would have eliminated almost as many graduates as attrites from school selection (444 - 370 = 74 graduates vs. 243 - 167 = 76 attrites). At scores over 214, more graduates than attrites were eliminated from school selection.

For the AW "A" school (Table E-2), the attrition rate was 18 percent, which warrants a raise in the minimum qualifying score. Raising the minimum qualifying score for AR+2MK+GS from 196 to 202 would have increased the graduation rate by 2 percent (from 83% to 85%). However about twice as many graduates as attrites would have been eliminated from school selection (698 - 644 = 54 graduates vs. 143 - 117 = 26 attrites). The 2 to 1 elimination ratio (graduates to attrites) was maintained for scores above 202 as increasingly larger numbers of graduates were eliminated from qualifying for the AW "A" school.

Minimum Qualifying Scores: OS, SM, and QM "A" Schools

For the OS and SM "A" schools (Appendix F), minimum qualifying scores for the proposed composite, VE+MK+CS, were evaluated using the Taylor Russell tables (1939). These tables are used rather than the expectancy tables developed from school data because the replacement composite cannot be accurately evaluated for a sample of students selected by a correlated operational composite.[4]

For the OS "A" school (Table F-1), a minimum qualifying score of 153 for VE+MK+CS would have qualified the same percentage of the recruit population (60%) as did the operational composite with the current minimum qualifying score, however, with an expected 1-percent increase in the graduation rate (from 86% to 87%).[5] Because the yearly input for the OS "A" school is high (approximately 2,000 students), raising the minimum qualifying score above 153 might create a shortage of qualified students.

For the SM "A" school (Table F-2), a minimum qualifying score of 147 for VE+MK+CS would have qualified 15 percent more of the recruit population than now qualify (75% - 60%) with only

[4]Improvements in the graduation rate may be inflated because a replacement composite analyzed for the school data is a second screen.

[5]The percentage of the recruit population qualifying for a school at a particular minimum qualifying score is expressed as a proportion, or selection ratio, in the Taylor Russell tables.

a 1 percent reduction in the expected graduation rate (94% - 93%). The 147 score, recommended for the RM "A" school (Held, 1987), is appropriate for the SM "A" school because (1) the SM and RM "A" schools require similar abilities, (2) SM waivers (students who scored lower than the minimum qualifying score) performed as well as did nonwaivers (93% graduation rate for both), suggesting that a higher percentage of the recruit population could be made school-qualified without increasing attrition, and (3) waivers constituted 15 percent of the SM sample, suggesting that the SM "A" school may have difficulty filling its yearly input requirement and would benefit from having a larger recruit selection pool.

For the QM "A" school (Table F-3), a minimum qualifying score of 193 for AR+2MK+GS would qualify the same percentage (70%) of the recruit population as did the operational composite with the current minimum qualifying score, but with an expected 2-percent increase in the graduation rate (from 84% to 86%). Because attrition for the QM "A" school was only 5 percent for the first four months of FY87, a higher minimum qualifying score is not warranted.

RECOMMENDATIONS

The following recommendations are addressed to PERS-23:

1. For the AC and AW "A" schools, the operational composite, AR+2MK+GS, is recommended for continued use. This composite is also recommended to replace the operational selector composite, VE+AR, for the QM "A" school. The recommended minimum qualifying scores for AR+2MK+GS are (1) 214 for AC, (2) 202 for AW, and (3) 193 for QM.

2. For the OS and SM "A" schools, VE+MK+CS is recommended to replace the operational selector composite, VE+AR. The recommended minimum qualifying scores for VE+MK+CS are 153 for OS and 147 for SM.

Adopting these recommendations and those made from the RM and AG studies should reduce attrition for the OA occupational group and the number of operational selector composites from three to two.

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APPENDIX A

ANALYSES FROM THE RM AND AG VALIDATION STUDIES

ANALYSES FROM THE RM VALIDATION STUDY

The validation and minimum qualifying score analyses that were conducted for the Radioman (RM) validation study (Held, 1987) are summarized on pp. A-1 and A-2.

For the validation analysis, Methods I and II identified the same experimental composite, MK+CS+AR+VE, using the test selection sample. The validities for this composite and for the operational composite, VE+NO+CS, in the hold-out sample (r_u, uncorrected for restriction in range; r_c, corrected for restriction in range) are listed in Table A-1.

Table A-1

Experimental and Operational Selector Composite Validities for the RM Hold-out Sample

	Experimental Methods I & II		Operational Selector Composite	
School	r_u	r_c	r_u	r_c
RM	.43	.55	.29	.47

The corrected validity for the experimental composite was .08 higher than the validity for the operational composite (.55 - .47). This gain was enough to consider replacing the operational composite. Of three candidate composites chosen from the Navy's 11 operational selector composites, VE+MK+CS had the highest validity (.53) and, therefore, was recommended as the operational selector composite for the RM "A" school.

The analysis that evaluated minimum qualifying scores for the recommended composite, VE+MK+CS, using the Taylor Russell tables is given in Table A-2.

Table A-2 shows a 3-percent expected increase in the graduation rate (from 84% to 87%) using VE+MK+CS with a minimum qualifying score of 147 versus using the operational composite with the current minimum qualifying score of 144. With VE+MK+CS=147, 75 percent (or selection ratio of .75) of the recruit population qualify for RM selection.

Table A-2

Evaluation of VE+MK+CS Minimum Qualifying Scores for RM

Selection Ratio	Selector Composite Minimum Qualifying Scores: Operational (VE+NO+CS)	Selector Composite Minimum Qualifying Scores: Proposed (VE+MK+CS)	Percent Expected to Graduate: Operational r_c = .47	Percent Expected to Graduate: Proposed r_c = .53	Percent Improvement
.85	**144[a]**	**141**	**84**	**85**	**1**
.80	147	144	85	86	1
.75	**149**	**147[b]**	**86**	**87**	**1**
.70	152	149	87	88	1

Note. See first page of Appendix F for an explanation of the table.
[a]Current minimum qualifying score (144).
[b]Recommended minimum qualifying score (147).

ANALYSES FROM THE AG VALIDATION STUDY

The validation and minimum qualifying score analyses that were conducted for the Aerographer's Mate (AG) validation study (Monzon, 1987) are summarized below and on p. A-3.

For the validation analysis, Methods I and II identified the same experimental composite, MK+MC+AR+GS, using the test selection sample. The validities for this composite and for the operational composite, VE+AR, in the hold-out sample (r_u, uncorrected for restriction in range; r_c, corrected for restriction in range) are listed in Table F-3.

Table A-3

Experimental and Operational Selector Composite Validities for the AG Hold-out Sample

School	Experimental Methods I & II: r_u	Experimental Methods I & II: r_c	Operational Selector Composite: r_u	Operational Selector Composite: r_c
AG	.40	.61	.27	.55

The corrected validity for the experimental composite was .06 higher than the validity for the operational composite (.61 - .55). This gain was enough to consider replacing the operational selector composite. The validity for the one candidate composite chosen from the Navy's 11 operational selector composites, AR+2MK+GS, was .62. Therefore, AR+2MK+GS was recommended as the operational selector composite for the AG "A" school.

The analyses that evaluated minimum qualifying scores for the recommended composite, AR+2MK+GS, using the Taylor Russell tables are given in Table A-4.

Table A-4

Evaluation of AR+2MK+GS Minimum Qualifying Scores for AG

Selection Ratio	Selector Composite Minimum Qualifying Scores		Percent Expected to Graduate		Percent Improvement
	Operational (VE+AR)	Proposed (AR+2MK+GS)	Operational $r_c = .55$	Proposed $r_c = .62$	
.45	106	211	87	89	1
.40	**108[a]**	**214[b]**	**88**	**91**	**3**
35	109	218	89	92	3
.30	111	221	91	93	2

Note. See first page of Appendix F for an explanation of the table.
[a]Current minimum qualifying score (108).
[b]Recommended minimum qualifying score (1214).

Table A-4 shows a 3-percent expected increase in the graduation rate (from 88% to 91%) using AR+2MK+GS with a minimum qualifying score of 214 versus using the operational composite with the current minimum qualifying score of 108. With AR+2MK+GS=214, there is no change in the percentage (40% or selection ratio of .40) of the recruit population that qualify for AG selection.

APPENDIX B

SCORING OF FAILURES

SCORING OF FAILURES

The scoring of failures procedure is based on the assumption that, for a population of Navy applicants, the combined distribution of final school grade (FSG) for graduates and attrites is normal. On the basis of the mathematical properties of a normal curve, a mean FSG for attrites can be calculated at the appropriate lower point of the FSG distribution given the following values.

p = the proportion of graduates.

q = the proportion of attrites.

$\overline{X}_g$ = the mean FSG for graduates.

SD_g = the standard deviation of FSGs for graduates.

z = the z-score (standard score) above which the proportion, p, falls.

y = the height of the normal curve at z.

Step 1

The mean FSG for attrites, $\overline{X}_a$, can be determined as follows:

$$\overline{X}_a = \overline{X}_g - A(SD_g), \text{ where } A = \frac{y/(pq)}{\sqrt{1+ (zy/p) - (y/p)^2}} .$$

Step 2

Assign the estimated mean criterion score determined in step 1 to each attrite.

Step 3

Compute the correlation between each predictor and the criterion for the combined distribution of graduates and attrites.

Step 4

Correct the correlations from step 3 for coarse grouping (the fact that a single criterion score has been assigned to attrites, therefore underestimating the variance and the correlation coefficient). The formula used for this correction is:

$r_c = r_{xy}/SDz'$, where

$$SDz' = \sqrt{1 - q + zy + y^2/q} .$$

The following is a computational example of the procedures for assigning a mean FSG to attrites using AW "A" school data.

p = the proportion of graduates = 740/908 = .82

q = the proportion of attrites = 168/908 = .18

$\overline{X}_g$ = mean FSG for graduates = 87.668

SD_g = standard deviation of FSG for graduates = 5.687

z = the standard score above which the proportion, p, falls = -0.92

y = the height of the normal curve at z = .2613

The mean FSG for attrites, $\overline{X}_a$, as determined by step 1 from the previous page is:

$$\overline{X}_a = \overline{X}_g - A(SD_g), \text{ where } A = \frac{.2613/(.82 \times .18)}{\sqrt{1 + (-0.92 \times .2613) / .82 - (.2613 / .82)^2}}.$$

Thus, A = 2.9248

and, $\overline{X}_a$ = 87.668 -(2.9248 x 5.687) = 71.035, or approximately 71.

Illustrated next is the correction for coarse grouping procedure (step 4). The correlation between the experimental composite, AR+MC+VE+MK (derived in the AW test sample) and final school grade is .4041. This correlation, corrected for coarse grouping is:

r_c = .4041/SDz′, where

$$SDz' = \sqrt{1 - .18 + (-0.92)(.2613) + (.2613)^2 / .18}.$$

= .9589

r_c = .4041/.9589

= .4214.

APPENDIX C

CORRECTION PROCEDURE USED IN METHOD II

CORRECTION PROCEDURE USED IN METHOD II

In order for the regression analysis used to derive the ASVAB composite most predictive of final school grade (FSG) not to be biased against tests used for school selection, test scores must be corrected for restriction in range. This is accomplished in Method II by using a Navy applicant population ASVAB/FSG intercorrelation matrix where correlations between ASVAB tests and FSG are estimated using multivariate correction formulas (Lawley, 1943).

The next page gives two intercorrelation matrices (including means and standard deviations) required for the multivariate correction procedure. The first is the ASVAB/FSG intercorrelation matrix for the AW test selection sample (see Table 1 for the full test names). The second is an ASVAB intercorrelation matrix for a Navy applicant population. At the bottom of the page are the estimated correlations between ASVAB tests and FSG for the population.

AW Test Selection Sample Intercorrelations
with Means and Standard Deviations

	GS	AR	NO	CS	AS	MK	MC	EI	VE	FSG	Mean	SD
GS	1.000	.276	.036	.055	.307	.299	.365	.424	.599	.210	57.20	5.86
AR		1.000	.285	.231	.298	.548	.430	.322	.377	342	55.21	5.97
NO			1.000	.534	.021	.290	.053	.039	.103	.189	53.02	6.81
CS				1.000	.023	.193	.126	.163	.186	.234	53.58	6.76
AS					1.000	.160	.478	.545	.391	.129	57.61	6.83
MK						1.000	.389	.304	.363	.348	54.40	6.36
MC							1.000	.485	.423	.262	57.71	6.48
EI								1.000	.488	.190	56.98	6.92
VE									1.000	.219	55.41	5.01
FSG										1.000	85.42	7.13

Population (Applicant FY86) Intercorrelations
with Means and Standard Deviations

	GS	AR	NO	CS	AS	MK	MC	EI	VE	Mean	SD
GS	1.000	.601	.234	.223	.505	.591	.635	.666	.773	52.30	8.28
AR		1.000	.464	.377	.409	.740	.630	.528	.626	51.46	8.22
NO			1.000	.616	.027	.460	.218	.139	.314	51.74	8.26
CS				1.000	.039	.365	.212	.152	.331	53.13	7.86
AS					1.000	.269	.636	.658	.437	52.99	9.14
MK						1.000	.558	.476	.551	50.64	8.71
MC							1.000	.661	.582	51.98	8.88
E								1.000	.593	53.25	8.67
VE									1.000	52.17	7.06

Correlations (Validities) for Population from Multivariate
Correction Program and above Matrices

	GS	AR	NO	CS	AS	MK	MC	EI	VE
FSG	.434	.528	.334	.349	.244	.529	.432	.348	.412

APPENDIX D

MULTIPLE REGRESSION FOR METHODS I AND II

MULTIPLE REGRESSION FOR METHODS I AND II

AW Test Selection Sample
Method I (MK+AR+CS+GS)

TEST	STEP	MULTR	RSQ	F	FSIG	RSQCH	FCH	SIGCH	REG-DF	RES-DF
MK	1	.3482	.1212	74.92	.000	.1212	74.92	.000	1	543
AR	2	.3921	.1537	49.23	.000	.0325	20.80	.000	2	542
CS	3	.4177	.1745	38.11	.000	.0208	13.60	.000	3	541
GS	4	.4273	.1826	30.16	.000	.0081	5.36	.021	4	540

Recruit Applicant Population (FY86)
Method II (MK+AR+CS+MC)

TEST	STEP	MULTR	RSQ	RSQCH
MK	1	.5290	.2798	.2798
AR	2	.5666	.3210	.0411
CS	3	.5824	.3392	.0182
MC	4	.5912	.3495	.0104

The multiple regression results (SPSS^{x}, 1983) for Method I show that AR is entered into the composite equation at Step 2, at which point the multiple correlation for the composite MK+AR is .3921. The squared multiple correlation (the proportion of final school grade variance accounted for by the composite) is .1537. The F statistic to determine the significance of the predictive relationship between the composite MK+AS and final school grade is 49.23. The probability that this predictive relationship is due to chance is less than .001. The change in the squared multiple correlation upon entering this test (AR) into the equation is .0325. The F statistic for change (to determine the significance of the increase in the predictive relationship by adding the test AR into the equation) is 20.80. The probability that the significance of this addition is due to chance is less than .001. The degrees of freedom (number of observations minus number of estimated parameters) are 2 for regression and 542 for residual.

Method II is based on corrected correlations. Since there are no appropriate significance tests for corrected correlations, the F tests for this method do not apply.

APPENDIX E

EXPECTANCY TABLES FOR THE AC AND AW "A" SCHOOLS

EXPECTANCY TABLES FOR THE AC AND AW "A" SCHOOLS

The following tables show a range of operational selector composite scores for the AC and AW "A" school samples that include the current and proposed minimum qualifying score. A breakdown for each score includes actual graduation and attrition rates for the school sample and expected rates (per 1,000) for the recruit population (FY86, N = 89,816).

Table E-1

Expectancy Table for the Operational Selector Composite (AR+2MK+GS) for the AC "A" School (N = 751)

Composite Score	School Sample					At or Above Composite Score in Recruit Population (%)	Expectancies per 1,000 Recruits		
	Grad N	Drop N	Total N	Grad (%)	Drop (%)		Total N	Grad N	Drop N
≥ 167	477	274	751	64	36	95	950	608	342
≥ .	.	.	.	.	.	.	.	.	.
≥ .	.	.	.	.	.	.	.	.	.
≥ 204	457	253	710	64	36	52	520	333	187
≥ 205	453	250	703	64	36	51	510	326	184
≥ 206[a]	**444**	**243**	**687**	**65**	**35**	**50**	**500**	**325**	**175**
≥ 207	441	235	676	65	35	49	490	318	172
≥ 208	431	221	652	66	34	47	470	310	160
≥ 209	427	212	639	67	33	46	460	308	152
≥ 210	417	204	621	67	33	45	450	302	148
≥ 211	407	193	600	68	32	44	440	299	141
≥ 212	394	182	576	68	32	43	430	292	138
≥ 213	380	171	551	69	31	42	420	290	130
≥ 214[b]	**370**	**167**	**537**	**69**	**31**	**40**	**400**	**276**	**124**
≥ 215	358	159	517	69	31	39	390	269	121
≥ 216	350	147	497	70	30	38	380	266	114
≥ 217	338	140	478	71	29	37	370	263	107
≥ 218	323	133	456	71	29	36	360	256	104
≥ 219	313	128	441	71	29	35	350	249	101
≥ .	.	.	.	.	.	.	.	.	.
≥ .	.	.	.	.	.	.	.	.	.
≥ 265	1	0	1	100	0				

Note. Of the 64 waivers (those who scored below the minimum qualifying score of 206), 31 (48%) attrited (attrites are designated as drops). Waivers represent 8.5 percent of the total sample.

[a]Current minimum qualifying score.

[b]Proposed minimum qualifying score.

Table E-2

Expectancy Table for the Operational Selector Composite (AR+2MK+GS) for the AW "A" School (N = 908)

Composite Score	School Sample					At or Above Composite Score in Recruit Population (%)	Expectancies per 1,000 Recruits		
	Grad N	Drop N	Total N	Grad (%)	Drop (%)		Total N	Grad N	Drop N
≥ 156	740	168	908	82	18	99	990	812	178
≥ .	.	.	.	.	.	.	.	.	.
≥ .	.	.	.	.	.	.	.	.	.
≥ 194	709	148	857	83	17	65	650	540	110
≥ 195	705	146	851	83	17	64	640	531	109
≥ 196[a]	**698**	**143**	**841**	**83**	**17**	**62**	**620**	**515**	**105**
≥ 197	692	141	833	83	17	61	610	506	104
≥ 198	674	136	810	83	17	60	600	498	102
≥ 199	669	133	802	83	17	59	590	490	100
≥ 200	662	130	792	84	16	57	570	479	91
≥ 201	654	126	780	84	16	56	560	470	90
≥ 202[b]	**644**	**117**	**761**	**85**	**15**	**55**	**550**	**468**	**82**
≥ 203	637	114	751	85	15	54	540	459	81
≥ 204	624	110	734	85	15	52	520	442	78
≥ 205	612	105	717	85	15	51	510	434	76
≥ 206	589	97	686	86	14	50	500	430	70
≥ 207	581	95	676	86	14	49	490	421	69
≥ 208	566	90	656	86	14	47	470	404	66
≥ 209	555	90	645	86	14	46	460	396	64
≥ .	.	.	.	.	.	.	.	.	.
≥ .	.	.	.	.	.	.	.	.	.
≥ 270	2	0	2	100	0				

Note. Of the 67 waivers (students who scored below the minimum qualifying score of 196), 25 (37%) attrited (attrites are designated as drops). Waivers represent 7 percent of the total sample.

[a]Current minimum qualifying score.

[b]Proposed minimum qualifying score.

APPENDIX F

EVALUATION OF PROPOSED COMPOSITE MINIMUM QUALIFYING SCORES FOR THE OS, SM, AND QM "A" SCHOOLS

EVALUATION OF PROPOSED COMPOSITE MINIMUM QUALIFYING SCORES FOR THE OS, SM, AND QM "A" SCHOOLS

The Taylor Russell tables (1939) are used to predict improvement in the personnel success rate that would result from use of a more valid selection instrument. The tables, derived for this Appendix, use the following information: (1) the selection ratio, which is the proportion of the applicant population to be hired (for Navy use, it is the percentage of recruits qualified for school selection at a specified minimum qualifying score), (2) validity of the selection instrument (ASVAB selector composite), and (3) base rate, which is the success rate without having used a selection instrument (unknown for the Navy, but determined by the first two variables and the known school graduation rate).

Tables F-1, F-2, and F-3 give selection ratios and corresponding minimum qualifying scores for the operational and proposed selector composites for the OS, SM, and QM ratings, respectively. Also given are the validities for the operational and proposed selector composites, the percentages expected to graduate from "A" school using each composite with the various selection ratios (or minimum qualifying scores), and the difference of these expected rates as a percent improvement.

Table F-1

Evaluation of Proposed Composite Minimum Qualifying Scores for the OS "A" School

Selection Ratio	Selector Composite Minimum Qualifying Scores		Percent Expected to Graduate		Percent Improvement
	Operational (VE+AR)	Proposed (VE+MK+CS)	Operational $r_c = .29$	Proposed $r_c = .35$	
.70	99	149	84	85	1
.65	100	151	85	86	1
.60	**102[a]**	**153[b]**	**86**	**87**	**1**
.55	103	155	87	88	1
.50	105	157	87	89	2

Note. The validity of a composite, r_c, is a Pearson product-moment correlation corrected for restriction in range of test scores.

[a]The current minimum qualifying score for the operational composite for the OS school is 103, which qualifies 57.5 percent of the FY86 recruit population. These two values differ from those of the table because the table values are based upon a normal distribution of scores, which is only approximated by the recruit population distribution of scores.

[b]Recommended minimum qualifying score for the proposed composite (153).

Table F-2

Evaluation of Proposed Composite Minimum Qualifying Scores for the SM "A" School

Selection Ratio	Selector Composite Minimum Qualifying Scores		Percent Expected to Graduate		Percent Improvement
	Operational (VE+AR)	Proposed (VE+MK+CS)	Operational $r_c = .33$	Proposed $r_c = .40$	
.75	**97**	**146(147)[a]**	**93**	**93**	**0**
.70	99	149	93	94	1
65	100	151	94	95	1
.60	**102[b]**	**153**	**94**	**95**	**1**
.55	103	155	95	95	0
.50	105	157	95	95	0

Note. The validity of a composite, r_c, is a Pearson product-moment correlation corrected for restriction in range of test scores.

[a]Recommended minimum qualifying score for the proposed composite (147).

[b]The current minimum qualifying score for the operational composite for the SM school is 103, which qualifies 57.5 percent of the FY86 recruit population. These two values differ from those of the table because the table values are based upon a normal distribution of scores, which is only approximated by the recruit population distribution of scores.

Table F-3

Evaluation of Proposed Composite Minimum Qualifying Scores for the QM "A" School

Selection Ratio	Selector Composite Minimum Qualifying Scores		Percent Expected to Graduate		Percent Improvement
	Operational (VE+AR)	Proposed (AR+2MK+GS)	Operational $r_c = .70$	Proposed $r_c = .74$	
.80	95	186	80	81	1
.75	97	189	82	83	1
.70	**99[a]**	**193[b]**	**84**	**86**	**2**
.65	100	197	86	87	1
.60	102	200	88	89	1

Note. The validity of a composite, r_c, is a Pearson product-moment correlation corrected for restriction in range of test scores.

[a]The current minimum qualifying score for the operational composite for the QM school is 98, which qualifies 70.9 percent of the FY86 recruit population. These two values differ from those of the table because the table values are based upon a normal distribution of scores, which is only approximated by the recruit population distribution of scores.

[b]Recommended minimum qualifying score for the proposed composite (193).

The expected improvement rates are based upon the performance of the current sample. These rates may differ for students selected in the future depending upon the extent to which differences occur in: (1) ability distributions and motivation and (2) conditions for selection (recruit population ability distribution, quota requirements, etc.). The FY86 Navy recruit population (N = 89,816) was used for these analyses.

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